W G Scott

REPORTS

OF

Moncure Robinson, Esq. & Col. Stephen H. Long,

ENGINEERS

APPOINTED BY THE CANAL COMMISSIONERS FOR EXAMINING THE DIFFERENT ROUTES FOR CROSSING THE ALLEGHENY MOUNTAIN, UNDER THE DIRECTIONS OF THE SECOND SECTION OF THE ACT PASSED MARCH 27, 1830, ENTITLED

"An act making further appropriations for Canals and Rail-Roads,"

TRANSMITTED BY JAMES CLARKE, ESQ. ONE OF THE CANAL COMMISSIONERS, IN PURSUANCE OF A RESOLUTION OF THE SENATE, ADOPTED ON THE 26TH OF FEBRUARY, 1831.

READ IN SENATE, MARCH 14, 1831.

HARRISBURG:
PRINTED BY HENRY WELSH.
1831.

REPORTS.

WILLIAM G. HAWKINS, ESQ.
Speaker of the Senate.

SIR—Having, in the absence of my colleages, received the reports of the engineers, Messrs. Robinson and Long, relative to a portage road over the Allegheny mountain, which they, in conjunction with Major Wilson, were appointed to survey during the last summer, I herewith transmit the same to you in obedience to a resolution of the Senate of the 26th January last.

Very respectfully,
Your obedient servant,
JAMES CLARKE.
Canal Commissioner.

Canal Office, Harrisburg, March 14, 1831.

To the Board of Canal Commissioners of the State of Pennsylvania.

GENTLEMEN:

It appears that the several engineers appointed under the act of the 27th of March last, to inspect the several routes and report in relation to the Allegheny portage, concur in deeming a rail road preferable to a Macadamized road, and in awarding their preference to "a route leading upwards along the vallies of Blair's Gap run, crossing the Allegheny mountain at the Blair's Gap summit, and descending to Johnstown, in the valleys of Laurel Run and the Little Conemaugh;" but that two lines complying with the above conditions, are at issue before them; the one traced by the undersigned in 1829, and by him recommended to the canal commissioners, in his report of that year; the other traced by Lt. Col. Long, in the summer and fall of 1830.

As the opinions of the undersigned in regard to the superior eligibility of the line traced by him in 1829 remain unchanged, after a careful review of all the considerations, which appear to him to have an influence in the selection of a route, it now becomes his duty to say so, and to refer the board of canal commissioners to his report of 1829, and the accompanying documents for an exposition of his plans in detail. In doing so he does not mean to say that on a review of the line many improvements on particular portions of it might not be made. On the contrary he has in the report above alluded to, pointed out changes which it would be desirable to effect, and alluded to blemishes which on a final adjusment of the line, it would be advantageous to avoid. But he is satisfied that the line in all its important features will be found the most advisable, and particularly in those by which it is distinguished from the line traced during the past season, by Lt. Col. Long.

The undersigned does not mean to enter into an unnecessary and invidious analysis of the two lines. He deems it however, under the circumstances stated, due to the canal commissioners and to himself, as well as to the great interests which rest on the execution of the proposed improvement, in the most judicious manner to compare them in those respects in which they most widely differ, and to present in as brief a manner as possible, some views which appear to him decisive on the subject.

The line traced by Col. Long appears to be the result of "a course of examinations and surveys, the leading objects of which were to obviate the necessity of constructing a tunnel at the summit till such time as the exigencies of the trade upon the road should require it: to avoid the adoption of inclined planes, having inclinations greater than five degrees, and if possible to limit their inclinations to three degrees; to provide for a route upon which not only *stationary* but *progressive* power might operate to advantage, according to circumstances; to effect a definitive location of a route upon ground most favourable for the construction of a road in regard to the principles as well as to the cost of construction," &c.

The results of the course of examinations and surveys of Col. Long are, that the necessity of a tunnel at the summit is obviated by encountering that very summit which the tunnel was recommended to avoid, with the exception of "a deep cut about 1500 feet long, the greatest depth of which will be eighteen feet." In avoiding the adoption of inclined planes, having inclinations greater than five degrees, and in limiting their inclination to three degrees, eleven inclined planes (the whole number required) have been located, *not one of which is straight*, and several of which present in the opinion of the undersigned curvatures altogether inadmissable. In his report of November 1829, the undersigned had observed that "the bold outlines of the country did not admit of prescribing to it too many conditions." He will endeavor to shew that the condition of having inclined planes in no case exceeding five degrees, and in most cases under three degrees, which would lead in every case to the substitution of curved planes for the straight planes located by him in 1829, is an unnecessary and inapplicable one, and that such a substitution would be in every way prejudicial to the contemplated improvement. It will be proper, however, to examine the features in which the two lines most widely differ, in the order in which they have been presented, and

First, as to the tunnel.

In the investigation of this subject and of every other connected with the Allegheny portage, it seems to the undersigned very clear that we can arrive at no conclusion which has not referenceto the amount and character of the trade to be accommodated on it, or which is not based upon a "consideration of what the exigencies of the trade" may require. If it is doubtful whether the trade in question may be a very small trade or a very large trade, and we must wait for experience to guide us, then it seems to him the engineers have hazarded a great deal in recommending a rail road instead of a Macadamized road, because it is evident that the latter would be justified by a trade much smaller than would be required to make the former a judicious scheme. But if on the other hand, the trade on the rail road will almost as soon as the work is brought into successful operation be very great, if it will at all approach what has been anticipated by the gentlemen of this state who have given most attention to the subject of its improvements, then it seems equally clear that an increased expenditure ought not in the first instance to be spared, which is to diminish forever afterwards *in a much greater ratio than the interest on that expenditure*, the annual charges on transportation.

If any inference is deducible from premises, if any conclusion can be predicated on circumstances, analogies, or probabilities, it would seem to be safe to predict, that a line of rail road would have nearly as large an amount of trade as it could accommodate, which is to unite all the lines of inland communication executed or projected in Pennsylvania, east of the Allegheny mountain with all those west of it; which must form a link in any combination embracing an eastern and western rail-road or canal; which is to connect Philadelphia with Pittsburg, and the great Mississippi valley and our inland lakes with the ocean. If it should not that it could result only from mistakes in plan or execution, or a misjudged economy in not executing the work on which so many other lines must depend for their usefulness in a manner commensurate with the purposes it was intended to subserve. The following considerations (presuming this view of the business to be accommodated on the proposed rail-road, to be correct,) appear to the undersigned conclusive in favor of a tunnel.

1st. All the examinations which have been so far made, shew a tunnel to be *necessary* to the location of *straight* inclined planes immediately east and west of the summit. A reference to the map presented by the undersigned in 1829, will illustrate this position, which it is presumed will not be disputed, and a consideration of the great importance of the object in view is reserved to a later period in this report.

2d. In depressing the summit level by a tunnel, we place it below an extensive coal field, more conveniently situated *in this case* than any other for the supply of bituminous coal to the towns and villages on the Juniata. In the event of such a work being executed, it is confidently believed that a coal trade sufficient to give a full preponderance to the trade going east and to lift up that going west, will be *created*, and that steam engines east of the summit may be altogether dispensed with. On the plan of Col. Long, (unless a much more expensive power, that of horses, is substituted,) six steam engines would be required east of the summit in addition to those wanted west of it.

3d. The elevation surmounted on the Allegheny mountain, even after reducing the summit by a tunnel, is one-fourth greater than has yet been encountered on any similar improvement, and the difficulty of accommodating a large trade on a rail-road of lifts and levels (superior as such an improvement certainly is to any other plan of overcoming elevations) increases evidently in a much greater ratio than in proportion to the elevation surmounted.—Ordinary considerations of prudence would seem under these circumstances to dictate to us when going beyond what has yet been effected, at least not to go farther than may be necessary to our purpose.

4th. In discarding a tunnel, we are increasing the distance between Philadelphia and Pittsburg, or increasing the length of the rail-road, so far as time and power are elements in estimating it, about *five miles*, and its disadvantagesa if not to an equal at least to a considerable extent.

The above remark is founded on the presumption that friction on a level line of rail-road may be estimated at 1 in 200; of course that 26 feet and 4-10ths of elevation would require the same power to overcome it, as an increase of one mile in distance; or that 131 feet of elevation the additional height of the summit on the portage (should a deep cut be substituted for a tunnel) would be equivalent to an increase of distance of five miles.

It is true that the disadvantages of a summit, or of increased elevation on a rail-road are not increased in a ratio correspondent with the increase of power necessary to overcome it, because stationary power which will generally be resorted to at summits, will be found in most cases cheaper than locomotives or horses, the most expedient and appropriate powers on levels; yet the cost of rope and wear and tear of machinery, will be found in all cases to constitute very large deductions from any superior economy in power, and under certain circumstances may be equivalent to them.

The undersigned trusts enough has been said to satisfy the board, that in recommending a reduction of the Allegheny summit by tunnelling, he submitted to them no hastily conceived or ill considered project. He has deemed it due to the board and to himself whatever may be the fate of the measure recommended by him, to shew that it is professionally correct. The board are too well acquainted with the duties and responsibilities of a civil engineer, to expect or to desire that their officers in forming their plans should look to their plausibility or popularity. They will expect of them to recommend such as they believe to be most eligible, and to leave to the proper authority to adopt or reject.

The undersigned will add that he was very well aware, in submitting in 1829 to the Board of Canal Commissioners a plan of crossing the Allegheny mountain by means of a system of inclined planes and stationary power, and of reducing the summit by a tunnel, that such a plan must necessarily experience distrust and opposition. It would have been singular indeed if it had not. The system recommended was new in all its features in Pennsylvania, and the first essays in the way of tunnelling in this State, had from a want of experience on the part of the undertakers, and from other causes, been unnecessarily expensive. Whilst therefore the undersigned experiences some regret he is not surprised, that he could not present his views to the board in a light as forcible as he would have wished. Since the date of his report much has occurred to familiarize the public with the subject of rail-roads generally, and the complete success of the Carbondale rail-road has enabled the board of canal commissioners to point to an improvement which illustrates more forcibly than any reasoning could, the advantages of the system proposed for the Allegheny mountain, The superiority of such a system, whatever may have been thought of it twelve months since, it is presumed is no longer questioned. However bold the assertion may be deemed, the undersigned entertains no doubt that five years hence, when the serious disadvantages of unnecessary elevation, of an unnecessary multiplication of engines, and of curvatures in inclined planes on rail-roads, are better understood than they appear at present to be, the expediency of tunnelling at the portage summit will be questioned as little.

It now becomes the duty of the undersigned to show that on the principles of Col. Long, as exposed in a published document on a former occasion, the expediency of tunnelling at the Allegheny summit is recommended by the consideration of *reduction in elevation alone.* The undersigned is far from concurring in all the views taken in the document referred to. But they will probably be deemed good authority as regards Colonel Long himself, when in the present instance that gentleman questions the expediency of a tunnel.

The undersigned here takes leave to refer to a report of the board of engineers of the Baltimore and Ohio Rail-road Company, made on the 20th of May, 1829, signed by S. H. Long, president of the board.

In that document the object of which is to present the result of enquiries made by the board of engineers, " in reference to the selection of a route for the rail-road from Parr's Spring Ridge to the Point of Rocks," the following views are taken:

" In accordance with an opinion advanced by this board on a former occasion, in reference to the inclination required for the spontaneous descent of carriages upon a rail-road constructed in the manner contemplated for the Baltimore and Ohio Rail-road, the cost of transportation upward, on an ascent of thirty-feet perpendicular height, whatever may be the distance, or in other words, the amount of power required to ascend an elevation of thirty-feet, in addition to that required on a level rail-road of the same extent, would at least be equivalent to that required for conveyance through a distance of one mile. Subsequent experiments on the Baltimore and Ohio rail-road, have contributed not only to establish the correctness of the opinion, but also to afford unequivocal testimony that an elevation considerably less than that just mentioned is to be regarded as an impediment more difficult to be overcome than the distance of a mile on a horizontal road. Nevertheless we shall, on the present occasion, adhere to our former mode of estimating the disadvantages attendant upon ascents, and regard an elevation of thirty feet as equivalent to one mile, so far as it relates to the cost of transportation. Agreeably to this assumption, the following table," &c.

It will be unnecessary to give at length the tables which follow. Among the conclusions deduced is this, that on the tonnage anticipated for the Baltimore and Ohio rail road, the annual difference in the cost of transportation corresponding to a difference in equated distances of eight miles and eleven hundred and sixty-five yards, will be *seventy-seven thousand and nine hundred and fifty dollars.*

The above views are submitted without comment. The trade on the Allegheny portage may certainly without hazard of overoverrating it, be expected to be equal to that on the Baltimore and Ohio rail-road; and suppposing the conclusions of Col. Long to have been even approximately correct, it would be most misjudged economy to dispense with a tunnel, were no expensive substitutes in question, and even if its whole cost could be saved.

The undersigned would now leave the subject of the tunnel, but opinions so exaggerated of its cost and difficulty have been entertained, and so generally, that he is induced to trespass on the indulgence of the board, with a few very simple comparisons. If they produce in the present instance no practical result, they may perhaps be useful in inducing a juster appreciation of similar undertakings hereafter.

The whole estimated cost of the Allegheny portage tunnel, was $165,571 20. This amount like all the items of his estimate, was deemed liberal at the time, but the completion of the Liverpool tunnel, a work of much greater magnitude and difficulty for a smaller sum, shews it to have been much more than ample.

The height of the Liverpool tunnel is 16 feet, its breadth 22 feet, and its length 2200 yards.

Its excavation of course must have been 39½ yards, per lineal yard, and the whole cubic content 86,044 yards.

The whole amount of excavation of the proposed Allegheny portage tunnel is 50,698 yards.

The cost of the Liverpool tunnel, exclusive of compensation to individuals for houses destroyed, and other damages, was £ 34,770 sterling, or estimating the dollar at 4*s.* 6*d.* $154,533.

And the Allegheny portage tunnel, estimated at a proportionate rate would be $91,034.

In speaking of the Liverpool tunnel, Mr. Booth the treasurer of the company, observes, "But while some portions of the tunnel were excavated under circumstances of no little difficulty and danger, and requiring all the skill and energy of the engineer to accomplish, other portions were hewn through a fine red sandstone, clean dry and substantial, and requiring neither props nor artificial arching; the natural rock forming the roof of the excavation."

It was deemed by the undersigned proper, on account of the horizontal stratification of the Allegheny, to include in his estimate the expense of arching the whole length of the tunnel; but it is needless to say to any one, conversant with the geology of the Allegheny, that a tunnel there would be excavated through a sandstone as clean, dry and substantial, as any similar rock, and the excavation of which would of course be as favorable, as that of the most favorable portions of the tunnel at Liverpool.

The undersigned will now request the attention of the board of canal commissioners, to the second point in which the lines traced by himself in 1829, and by Lt Col. Long, during the past season, most materially differ, viz: the character of the inclined planes, traced on them. A mistake on this head will certainly be deemed far more serious than one in relation to the tunnel. If the tunnel should for the present be dispensed with, it may when found necessary at a later period be executed, and the best arrangement be then adopted, in relation to the planes immediately east and west of the summit; but a mistake in the location of the planes generally on the line, as it would influence the level and graduation of intermediate portions of it, might be deemed one of irreparaable evil, The undersigned begs leave therefore, to go into this subject at some length, and to introduce the following extract, from his report of 1829:

"Two points have been deemed to be of essential importance in the location of inclined planes. 1st. That they should be straight, and that the line of the rail-road should for a short distance, from the head and foot of each plane, be in the same direction with the plane; and 2ndly, that the plane itself should either have an uniform inclination with the horizon, or an inclination gradually diminishing between the head and foot of the plane. On a plane to any extent curved in its *plan*, a greater loss of power, and wear, and tear of cable or rope, will always be sustained than on a straight plane, and without a stage of some extent at the head of the plane, in the same direction with the plane, a very extensive business cannot be accommodated; and should the plane be so far curved as to prevent the manager at the head of the plane, from embracing its whole extent under his view, the operation of raising and lowering trains must be conducted by signals, and often disadvantageously."

"On planes on which power is to be applied, an inclination slightly diminishing towards the foot of the plane is most desirable; on self-acting planes, (where the fullest useful effect of the gravity of descending bodies is desired,) the most advisable profile is an approximation to the cycloid. It is in either case a disadvantageous feature, if the plane becomes steeper towards its foot. In the one case the engine at the commencement of its labor, is compelled to exert a greater force than is afterwards required. In the other, a descending train of wagons, may acquire in consequence of its increased stress combined with its accelerating force, a momentum not to be controlled by a brake, and attended with much hazard"

"It was farther an object in the case under consideration, to reduce the number of planes as far as practicable. Such a reduction was peculiarly recommended by the saving of time in transportation which it insured, and the superior simplicity of any system of transportation which might be adopted on the completion of the work."

Agreeably to the above views, nine out of ten planes were located, varying in their inclination from 3½ to 9½ degrees; and in one case, in order to command the whole water power of the Conemaugh, at a point midway the plane, an ascent of 26 degrees was admitted. In one of the planes only, was any curvature allowed in the plane, and in that case the extent of the curvature was an arc corresponding to a versed sine of forty feet on a chord of six hundred and seventy-two feet. All these planes, it will be observed, have an acclivity greater than three degrees, the limit which Col. Long deems most desirable. It will be proper, therefore, to ascertain whether any very strong considerations forbid such an increase of inclination.

It will perhaps on the first view, strike a superficial thinker, that the power of the engine required for a plane, must be increased in some degree in proportion to its acclivity. It will be perceived however at once, by a mind ever so little versed in the simplest elements of mechanics or machinery, that this is not the case; that to lift a weight a given height in a given time, the principle of the inclined plane requires an equal expenditure of power, whether it be steep or gentle; and in *practice* something more on a gentle plane, because the same amount of power must in each case be expended in overcoming the *gravity* of the load, while its *friction* on a gentle plane is of course in the ratio of its increased length. It will equally present itself that in increasing the acclivity of a plane, the *whole weight* of rope will not be increased, because presuming the plane to be twice as steep, and the *stress* on the rope of course to be doubled, the rope will on the other hand be but half as long, and the strength of rope, it is well known, increases in proportion to its cross section, or *to its weight in a given distance.*

It will be equally apparent on examination, that the whole weight of the drum or rope roll, and of the sheeves of the plane, will not at any rate be *increased* by an increase of acclivity.

If the theory of the inclined plane furnishes nothing to justify the limit of acclivity assumed by Lt. Col. Long, neither does the practice of British engineers. It is true that in *England proper,* one of the most champaign countries of Europe, the inclined planes of rail-roads are generally of but slight inclination. The elevations to be surmounted in that country are not often considerable, and it would in most cases have been difficult to have thrown a large amount of rise or fall into a small distance. Self-acting planes have been made gentle for an additional reason; because, as observes Mr. Wood in his treatise on rail-roads, "Where gravity is the moving power, it scarcely need be stated, that the strictest regard should be paid to economizing its effects. The power itself is acquired at no cost, and on that account should be extended to the utmost limit of its applicability."

But in that portion of the interior of England, in the neighbourhood of the Peak, which presents an aspect approximating in rudeness and boldness of outline to our own Allegheny, and in the mountains of Wales, the practice of British engineers is very different; and it is believed that the assertion may safely be hazarded, that not a single instance can be cited in those districts, in which under similar circumstances, planes of the gentle inclination proposed by Lt. Col. Long have ever been executed or proposed.

No improvement in the world presents so striking an analogy to the proposed Allegheny portage, as the Cromford and High Peak rail way. It connects two lines of canal, the Peak Forest and Cromford. Its summit is elevated 992 feet above the surface water of the latter, and the country over which it passes, presents obstacles of a smilar character. It seems to furnish us then a case in point, where the practice of those who have preceded us may lend us some aid. It may be added, that the work presents as a study the farther recommendation that it has been but lately executed, and of course those who projected and executed it, have had the advantage of all the recent improvements in rail-roads, and that it was planned and executed by Mr. Jessup, one of the most distinguished, among the many eminent civil engineers of Great Britain.

In the London Year Book, for the year 1830, the following statement is given of the inclined planes on that work:

1st	ascent	1740	feet long	204	feet	$\frac{1}{8.53}$	rise.
2nd	"	2133	"	261	"	$\frac{1}{8.17}$	"
3rd	"	2124	"	253	"	$\frac{1}{8.40}$	"
4th	"	1371	"	98	"	$\frac{1}{14}$	"
5th	"	2550	"	168	"	$\frac{1}{15.2}$	"
6th	descent	1980	"	266	"	$\frac{1}{7.44}$	"
6th	"	1365	"	191	"	$\frac{1}{7.13}$	"

In will be seen on examining the above inclinations that they vary between 3¾ and 8 degrees in surmounting a summit of 992 feet, and that the elevations overcome by the inclined planes vary between 98 and 266 feet; evidently shewing that the inclination as well as the extent of the planes was deemed a matter of no particular moment, and was governed by localities; and that the peculiar advantages of a plane not exceeding three degrees of inclination, were in a case similar to that under consideration, not perceived by Mr. Jessup.

In Wales the undersigned scarcely recollects an inclined plane under 10 degrees, and those that he saw in the mining districts of that province varied generally between 10 and 30 degrees; and he is informed by Captain M'Neil that he saw one on the Blaencuum rail road near Abergavenny as steep as 35 degrees.

It is scarcely worth while to add any thing farther on this subject. It will be seen on reference to the profiles submitted in 1829, that the range of inclination proposed by the undersigned on the Allegheny portage, with one exception, does not vary materially from that adopted by Mr. Jessup on the Cromford and High Peak rail way, and that in the case in question, an important object, that of securing a water power equal to the accommodation of any trade which can ever be anticipated on the portage, seems to recommend an increase of the angle of inclination of the plane. It will be agreed that this particular plane is *inconveniently* steep, and that but for the circumstance above stated, a different location would have been deemed more advisable; but it seems also equally clear that where a great elevation is to be surmounted, planes even if straight, may be inconveniently gentle, because they ought not to be more numerous than necessary, and in the language of Mr Sylvester, "the length of an inclined plane ought never to be such as will prevent a person from seeing the whole course of it from top to bottom."

The undersigned will now proceed to examine the character of the planes proposed by Col. Long, as substitutes for those to which attention has been drawn above, and he will premise, that however objectionable he thinks he can shew them to be, he deems their defects as necessarily resulting from the inapplicability of the system and principles on which they were traced. In a rugged country, like that over which the proposed connexion is contemplated, inclined planes must be located on the slopes and spurs of mountains often intersected with wide and deep ravines. It under these circumstances, may be deemed next to impossible, to trace a line descending at any given inclination, for a very considerable distance, without changing its direction, and therefore planes of gentle inclination must necessasily be *either more numerous than would be advisable, or curved.* Satisfied from his knowledge of the country that the principles adopted, and limits of inclination preferred by Lt. Col. Long would necessarily lead to this dilemma; and believing that an unnecessary multiplication of planes or curved planes were evils equally to be deprecated on a line of rail road as important as the one contemplated, the undersigned was induced to test the correctness of his views, by a comparison with those of two other gentlemen distinguished for scientific and practical attainments in the profession. The engineers alluded to were Mr. John B. Jervis, engineer of the Carbondale, and Albany and Schenectady rail roads, and Horatio Allen, Esq. engineer of the Charleston and Hamburg rail road, who it will be recollected was deputed to England by the Hudson and Delaware Coal Company to obtain information in relation to rail roads, and fixed and lomotive machinery generally. The following are extracts from the letters of these gentlemen in reply to his inquiries:

Mr. Jervis observes, speaking of the Carbondale rail road,—"our inclined planes are all straight. I should deem it a great objection to have such a curve as would prevent the men from seeing the operation from end to end. A moderate curve may be admitted, but I should want a strong inducement to admit any essential curving on a plane that had heavy work to perform. I should vary the inclination very much before I would curve for a road that had extensive business, or incur more expense in construction."

Mr. Allen in a letter of the 22d of January says: "I would decidedly prefer increasing the acclivity very considerably before I should admit a change of direction in the plane, and when following this principle would lend to extreme cases of ascent, I think I should increase the *number* of planes rather than introduce curvatures. The sources of derangement and accident are sufficiently numerous in inclined planes, without adding those which are inseparable from curves."

The annexed volume marked P. exhibits protractions of the planes traced by Col. Long, and proposed by him as substitutes for the straight planes which have been the subject of examination. The undersigned confesses, that he feels some reluctance at going into an argument, to prove the injudiciousness of adopting such planes on such a work as the Allegheny portage. He has no hesitation in saying, that on those of them which present the largest amount of curved line, an endless rope or chain, (the machinery which except under particular circumstances should be preferred on a plane of uniform inclination,) if it could be worked at all, would be cut to pieces almost immediately, and he thinks it would not be difficult to shew that the waste of power and wear and tear of machinery, on any plan of working which might be proposed, would be immensely increased.

Col. Long has not, however, submitted to the board of canal commissioners his views as to the manner of transportation on the proposed rail-road, and his estimate it will be observed embraces no item for machinery of any kind. The undersigned is therefore without a fact, to indicate to him the plan of working which Col. Long proposes for his planes. Under these circumstances he begs leave to submit the following views in illustration of the position he has taken, the force of which he thinks will be appreciated by the board, and admitted by scientific individuals who may chance to peruse them.

The plan of applying stationary power on planes, which is attended with the least friction of rope, is that which purposes attaching the load to the end of the rope, on the reciprocating system. Such a plan of working would be in general unadvisable on planes having an uniform angle of ascent, because, as must be obvious the engine has on this plan, not only to raise its load, but the weight of the rope to which it is attached, and which on any plan of endless machinery would be counterbalanced by the extension of the rope along the opposite descending track. The increased friction of ropes by curves will however be considered on the plan first suggested, *because on that plan it is smallest.*

Now on a straight plane of any length or elevation, the friction on the rollers is evidently in proportion to the weight of rope, and on any one roller is as the rope resting on that roller, or as R.

But if the plane be curved, then the stress on each roller is made up not only of the weight of the rope, but of the *resultant of two forces,* viz: the *stress of the load* (including the stress and friction of the portion of rope below the roller) and *at least an equal force* required to overcome this stress; or supposing:

S—the stress of the load, and rope below any given roller.

D—the distance between the rollers on the plane, and

V—the versed sine of a portion of the arc between any two *alternate* rollers.

Then the pressure on any roller on a curved plane $P = R + \frac{2vs}{D}$

Applying this formula, and selecting from Wood on rail-roads as the subject of investigation the plane which approximates most nearly to the standard of limitation (three degrees) preferred by Lt. Col. Long, we have a straight plane 2325 feet long, with a rise of 115 feet, on which a rope 7¼ inches in circumference is made use of to raise seven loaded carriages weighing 9408 lbs. each. The rollers on the plane appear to have been about 20 feet apart.

Now the pressure on each roller of the above plane or the quantity R. of the above formula would be simply the weight of 20 pounds of 2¼ inch rope or about 18 pounds.

Let us suppose a plane precisely similar to the above, except that it should be curved in arcs of 600 feet radius. Presuming the load to be precisely what it is stated in Wood.

The stress on the rope, comprising both the gravity and friction of the load, and estimating this last at 1 in 150 in consequence of the curvature of the plane, would be at a point near its foot $= \frac{9408 \times 7 \times 115}{2325} + \frac{9408 \times 7}{150}$ or 3697 pounds; and the versed sine of 40 feet in lengths of an arc of 600 feet radius is $\frac{33}{100}$ths of a foot. Then substituting the symbols in the above formula, we should have for the stress on a roller at the foot of the plane $18 + \frac{3697 \times .33 \times 2}{20} = 18 + 121 = 139$ lbs. Consequently the ratio of pressure, or of friction on the friction rollers or sheeves of the above planes near the foot of the planes is as 18 to 139 or as 1 to $7\frac{7}{10}$ths.

But it is evident that the pressure on each roller, commencing at the foot and advancing to the head of a plane, between the foot and head of a curved plane, increases rapidly, because we have to add both *the stress and friction of rope* below each roller, to the stress and friction of the load, in ascertaining (the resultant which gives us) the pressure on the roller; and it is to be recollected that in estimating this stress and friction, we are to estimate for a rope of larger dimensions than would be required on a straight plane, as well on account of the increased strain of the rope, as its increased wear and tear. It is not then hazarding too much to say, that the increased pressure in the cases above supposed, would be *at least ten fold* on the curved plane.

Now the friction of rope on the sheeves of a plane is of course, proportionable to the pressure, and whilst no rule can be laid down for determining the ratio of the wear and tear of rope, to the friction on the sheeves, (because a part of this wear and tear is experienced at the rope rolls, and results also from the rigidity of cordage and strain of the load.) we know that it depends very materially on it. The following considerations, shew that we ought to be very wary of increasing, (as we should in a formidable ratio, by curvatures in inclined planes,) a charge on transportation under any circumstances considerable.

On the Liverpool and Manchester rail-road, Mr. Booth in his late pamphlet on that rail-road observes, that, "the curves seldom exceed a deviation from a straight line of more than 4 inches in 22 yards; forming a segment of a circle, which if extended would embrace a circumference of 15 miles." Nevertheless in an estimate of the annual cost of transportation on that road by stationary power, made by Messrs. Walker and Rastrick, in 1829 the annual wear and tear of ropes on the road way, is estimated by the former gentleman, at upwards of £11,000 sterling, or one third of the whole expense of transportation: whilst by the last named engineer, the whole cost of transportation was estimated at £33,317, and the wear and tear of ropes alone at £ 14,820, a sum nearly equal to five-sixths of all other charges on transportation.

On the Rainhill and Sutton inclined planes, the annual expense of ropes alone was estimated by Mr. Walker, at £3315, or *at twice the amount of all other charges on transportion* on those planes.

In our own country, the wear and tear of rope, has been found by Mr. Josiah White, on a straight plane, to be equal to one and one fifth cents per ton, in *descending* 215 feet.

To these statements the undersigned begs leave to add the following extract, from the report of a deputation of the engineers of the Liverpool and Manchester rail-road, appointed to visit the rail-roads in the North of England, made at Liverpool, October 22, 1828.

"From New Castle, the deputation went to Sunderland, and visited that end of the Hetton rail-way, which terminates at the shipping place on the river Wear. The quantity of coal brought along this rail-way, was stated to be from 12 to 1500 tons. The rope was considerably thicker than on Mr. Thompson's rail way, and was stated by one of the engineers to be worn out in 4 or 5 months. The plane next the shipping place is 1968 yards long, worked by a forty horse engine. The curves near the port are very abrupt, and *must necessarily very much increase the wear and tear of the rope on that part of the line.*"

It is believed to be unnecessary to expose further, the serious evils which would arise on an important line of rail-road, from curvatures in inclined planes, to the extent proposed by Lt. Col. Long.

It will be observed that the undersigned, has so far avoided any investigation of the details of the line submitted by Col. Long. He is willing to presume if the out lines of his plan of improvement are judicious, its details are so likewise. One of the suggestions of Col. Long, in particular, the undersigned has certainly no objection to. This is the introduction of a tunnel, at one of the bends of the Conemaugh, by which the length of a line along the valley of that stream, may be reduced something more than a mile. He will unite with pleasure with Col. Long, in submitting this suggestion to the careful consideration of the engineer, who may execute the work, believing the object in view ought certainly to be attained, if the changes in the line necessary to effect it, would not in other respects impair it, and if it can be effected without introducing a curved plane, which on the line traced by Col. Long appears to result from it.

Presuming the Conemaugh tunnel proposed by Col. Long to be incorporated into his plan, the length of the line proposed by the undersigned would be about thirty-seven miles, instead of thirty-eight miles and fifty-three poles, as stated in his report of 1829. It will be observed by the canal commissioners, that the line of Lt. Col. Long, is stated as but about 35 and five-sixths miles. The causes of this *apparent* difference between the two lines, (for as they cross at the same summit, and are traced along the same valleys, and often alongside of each other, it is obvious it can only be apparent,) the board will at once know how to account for, by recollecting:

1st. That the length of the line traced by the undersigned in 1829, is computed to the head of the basin at Hollidaysburg; whereas that of Col. Long is terminated at the Hollidaysburg bridge, a point about three-eighths of a mile short of the basin.

2dly. The line of Col. Long has been traced in regular curves and tangents, an operation which always results in a reduction of distance, but which as it is a work merely of routine, and one of labour and expense, the undersigned is not in the habit of performing, until a line is definitely determined on, and a work about to be executed.

The undersigned ought not to close this report without adverting to the difference in the estimates of Col. Long and himself. The whole cost of the line surveyed by that gentleman it appears is but $611,700, whilst that of the undersigned, including the tunnel at the summit, is $ 936,000. The commissioners will not fail to remark that Col Long has made no estimate for steam engines or machinery of any kind, that nothing is included in his estimates for superintendence or contingencies; that they extend only to a point near the Hollidaysburg bridge; and that they do not include the lengths of rail road which *must* be made, parallel to each basin. Passing by these points, to which the undersigned respectfully requests the attention of the board, he begs leave to submit the following remarks with regard to the aggregate allowed by Col. Long, for road-way formation.

This item of expense, as the board well know, may be more or less; and it is among the most delicate of the duties of an engineer, and the one which requires the exercise of his best judgment, in contemplating an expenditure for this purpose, to have constantly in view the objects to be effected by an improvement. If the trade on a rail road is to be a small one, it is evidently injudicious td expend too large an amount for a more perfect accommodation of it. If it is to be a large trade, then sound economy will dictate such an expenditure in preparing the road bed, as will give to the power employed on the rail road its fullest useful effect, and reduce of course in the largest practicable proportion the expenses of transportation.

Believing as the undersigned did, that the Allegheny portage rail road, would if properly executed, have a larger trade than any similar work in this country, he did not in choosing a line select that which would be most easily formed into the road bed of a rail road, but that which seemed to him to possess the greatest *capabilities*, or on which a rail road when executed would be most valuable. He felt that a very small reduction on the charges of transportation would be more than equivalent to the interest of a large additional expenditure in first cost, and that it would be most injudicious economy for the sake of even a considerable saving in the preparation of the road bed, to tax forever afterwards the trade on the road unnecessarily. He confessess he should have deemed it as great a mistake to have feared a liberal expenditure where the object to be effected by it was so important, as to incur an extravagant one on a rail road destined for the accommodation of a small traffic.

The whole cost of road way formation for the Allegheny portage rail road according to the line and estimate of Lt. Col. Long, will it appears be "one hundred and eighty-two thousand one hundred and seven dollars and eighty cents, which gives for the average expense per mile inclusive of a tunnel, one thousand feet long, five thousand and eighty six dollars fifty-nine cents."

The undersigned would respectfully submit a single fact to the board.

He is executing in the anthracite district of this state a rail, road along the valley of a stream, (the Little Schuylkill) highly favorable to a work of the best description. As the object of the improvement was a special one, (the accommodation of a coal trade,) it will be conceived, that though it was deemed advisable to execute the work in a substantial manner, no unnecessary expenditure would be incurred on it. The cost of the road way of this rail road (20½ miles) executed under uncommonly favorable circumstances *exclusive of the wood work of bridges* will be about one hundred and five thousand dollars, or a larger average per mile, than is allowed by Col. Long for the road way formation of a rail road *including bridges* which is to cross the Allegheny mountain.

The undersigned would remark in closing this report, that in accepting the appointment which the board did him the honour to confer on him, he felt scarcely disposed to believe that any facts or views which might be developed on farther examination, would induce a change of the opinions expressed in his report of the 21st of November, 1829. He should indeed have performed his duty to the board but indifferently, and should have deserved very little their confidence had his plans been formed on such slight data; as to induce a belief that they would be materially changed, on further examinations of himself or of others. He was happy, however to meet the wishes of the board, and to have an opportunity of considering any suggestions on the part of the gentlemen with whom he was associated; and he has no doubt the canal commissioners will do him the justice to believe that if any other plan for cossing the Allegheny, had on reflection appeared to him preferable to that submitted by him in 1829, he would have had the candour to acknwoledge it.

He regrets that the opinions of Lt. Col. Long and himself differ so widely. That gentleman has however believed it his duty, to offer as a substitute for the line surveyed in 1829, one the merits of which the undersigned has certainly not perceived. He has had under these circumstances no alternative but to present the above investigation. This duty to the board and to himself being performed, the undersigned now takes leave of the subject.

All which is respectfully submitted,
MONCURE ROBINSON,
Civil Engineer.

Philadelphia, March 5, 1831.

To the Board of Canal Commissioners of the State of Pennsylvania.

GENTLEMEN:

In accordance with the concluding paragraph of your late annual report, dated at Harrisburg, Dec'r. 21, 1830, it remains for the engineers, who had the honour to be charged with the examination, &c., of the Allegheny portage, to submit an estimate of the cost of constructing a rail-road, leading across the Allegheny mountain. It accordingly becomes my duty, as one of the engineers alluded to, to present my views in relation to this question; which I shall attempt to do in the following order, and with a direct reference to the route surveyed and located, under my personal direction, during the last summer.

The route alluded to has the general locality designated in the report of 18th December last, and recommended as the route best adapted to a portage road: a more particular designation of this route may be given, as follows, viz: beginning at a point near Hollidaysburg bridge, and southwardly of the turnpike; thence proceeding westward, for a distance not exceeding one mile; thence crossing the turnpike, and pursuing a course northwardly of the same, and parallel to it about two miles; thence first diverging from, and then approaching the turnpike, maintaining a less circuitous course than the latter, about two miles farther; thence ascending the Allegheny mountain, on the north side and in the vicinity of the turnpike, and reaching the summit in a distance of about five miles farther at the point, or depression denominated Blair's Gap summit. It is proposed to cross the summit of the mountain by a deep cut, about 1500 feet long, the greatest depth of which, will be eighteen feet, thence pursuing a course westward of the summit, about 1¾ miles to its intersection with the turnpike, which it crosses at about the same distance from Lemmon's tavern; thence downward on the west side of the mountain, about 4 miles within the valley of Laurel run, and on the southeast side of the latter, to Lillys' mill, situated on the mountain branch of the Conemaugh; thence downward about 5½ miles on the south side of this branch, to the mouth of Beaver dam run, a little below which the route crosses the branch; thence downward on the north side of the mountain branch and Little Conemaugh, and within their vallies about 9½ miles to the upper bend of the Conemaugh, crossing the latter at an elevation of about 60 feet, thence about 7½ miles on the south side of the Conemaugh, passing through the gorge of the lower bend, by means of tunnel 1000 feet long, and terminating at the basin at Johnstown, making the aggregate extent of the route, from Hollidaysburg bridge to the Johnstown basin, about 36 miles.

In designating a point in the vicinity of the Hollidaysburg bridge, as the easterly termination of the route, I would not be understood as expressing a preference for this position, as the site of the basin at which the rail-road should terminate, but merely as a point from which the rail road may be prolonged downward, within the valley of the Beaver dam branch, to any point that may be hereafter be selected for its termination. The location of the basin at Johnstown, is regarded as dinitive of the westerly termination of the portage road, but no such location having been conclusively made on the east side of the mountain, I deem it sufficient to assume a point for the termination of the route, in that direction, from which the road may be conducted to any site upon the Juniata, best calculated to subserve the public interest.

The data upon which the subjoined estimates have been predicated and other circumstances illustrative of the character and condition of the route that has been located, are exhibited in the following details, viz: The width appropriate for the graded surface of a double rail road, or road with two tracks, is twenty five feet. The exterior slope deemed proper for earthen embankments, transversely of the road 33⅓ deg. or 1½ base to 1 perpendicular—the slope for excavations in earth 45 degrees—that for side-walls, excavations in rock, &c, $\frac{1}{5}$, or 1 base to 5 perpendicular. The slopes for piers and abutments of bridges is $\frac{1}{8}$ or 1 in 8, the thickness of parapet walls at their tops is 2½ feet. The curvatures on the route are generally limited to a radius of 603 feet, except in four instances, viz: 1st, at the Coal-bank run, east of the summit, 600 feet, at a radius of 550 feet; 2d, about one mile west of the summit, 1200 feet, at a radius of 573 feet; 3d, at Limestone run, 600 feet at a radius of 410 feet, and 600 feet at a radius of 573 feet; and, 4th, at Pringle's point, 600 feet at a radius 440 feet. At the point last mentioned, a line was run with particular care, in order to ascertain the practicability of a more gentle curvature, but on computation it appeared that the amount of excavation on a curve of 500 feet radius would amount to 25,778 cubic yards, in a distance of about 1000 feet, whereas the amount corresponding to a radius of 440 feet, is but 9896 cubic yards, in the same tance. The curvatures on other parts of the route vary in the extent of their radius, from 603 feet to about a mile.—Their localities may be readily ascertained by an inspection of the drawings herewith submitted.

The character of the route, with respect to ascents and descents, is exhibited in the following Table, in which are presented the lengths, inclinations, &c. of the several Inclined Planes, together with the extents and graduations of the intervening portions of the route, commencing at the head of Johnstown basin, and terminating at a point near the Holidaysburg bridge.

	Miles and feet.		INCLINATIONS.		Ascents and desc'nts
			Deg. Min.	Feet per mile.	
To foot of I. P. No. 11,	2	1740	0° 15′	23¼	54¼
head of do.		2000	2° 51′	264	95½
To foot of I. P. No. 10,	14	2552	0° 6′ to 0° 16′	25½ to 9.0	280
head of do.		2200	2° 51′	264	108
To foot of I. P. No. 9,	1	2620	0° 8′	13¼	19¾
head of do.		3000	2° 51′	264	144
To foot of I. P. No. 8,	1	3820	0° 8′ to 0° 10′	13¼ to 15¾	25¾
head of do		3100	2° 51′	264	149
To foot of I. P. No. 7,	2	40	0° 08′	13½	26½
head of do.		200	2° 34′	237½	234
To summit of mountain.	1	2220	0° 0′ to 0° 8′	0 to 13¼	177¼
DISTANCE ASCENDING,	26	2092	AGGREGATE ASCENT,		1154
To head of I. P. No. 6,		865	0	00	00
foot of do.		3912	4° 48′	443½	320
To head of I. P. No 5.		238	0	00	00
foot of do.		2969	4° 35′	422½	237¼
To head of I. P. No. 4.		531	0	00	00
foot of do.		5024	2° 51′	264	246
To head of I. P. No. 3.		4511	0° 19′	30	25¼
foot of do.		4700	2° 34′	237½	208¼
To head of I. P. No. 2,	1	260	0° 19′	30	31¼
foot of do.		4055	1° 50′ to 2° 18′	137¼ to 211¼	135¼
To head of I. P. No. 1,		200	0° 19′	30	1
foot of do.	1	920	0° 52′ to 1° 00′	68½ to 92½	102¼
To a point near Hollidaysburg bridge,	2	340	0 to 0° 30′	0 to 47½	78¼
DISTANCE DESCENDING,	9	2130	AGGREGATE DESCENT,		1381
TOTAL DISTANCE,	35	4222 or 35⅚ miles.			

A traverse of the entire route from Johnstown to Frankstown, has been worked out with much labor, with a view to determine the true bearing and exact distance on a right line, between those two points. The results thus obtained give for the bearing of Johnstown from Frankstown, S. 73° 52′ 30″ W. and for the distance 30.71 miles.

The more minute details developed by the surveys, are exhibited at full length, in the field notes, which were taken during their progress, a transcript of which, is herewith submitted, and in the accompaning plans and profiles of the route, which have been delineated on a scale of four inches to the mile, and exhibit all the information necessary to a clear understanding of the locality of every part of the route, and the features of the country adjacent thereto.

The field notes are comprised in three volumes, and exhibit courses and distances, the transverse slope of the ground, angle of deflection—the ascent or descents—the cutting or filling and the amount of excavation or embankment in cubic yards for each station of 100 feet in length, on the entire route.

The drawings constitute a single folio volume, entitled "drawings in plan and profile, illustrative of the surveys, made with a view to a portage road across the Allegheny mountain, under the direction of Lt. Col. S. H. Long, 1830," and are of the following import, viz:

1st. "Plan of a route surveyed for a portage road across the Allegheny mountain."—8 sheets.

2d. "Profile of a route surveyed for a portage road across the Allegheny mountain."—10 sheets (including "synopsis of grading, masonry, &c.")

3d. "A sketch of the Cedar swamp route, commencing at Newry and terminating at the confluence of the North and South Forks of the Little Conemaugh river."—6 sheets.

4th. "Sketches in plan and profile on the crest line of the Allegheny mountain, from Sugar run to the Cedar swamp gap."—7 sheets.

To which may be added a sketch of the Allegheny portage, exhibiting the several routes surveyed for a portage road, to be forwarded as soon as it can be completed.

In reference to that portion of the route situated between Limestone run and the mouth of the Ebensburg branch, it should be distinctly understood, that, although the surveys were executed in strict conformity to my instructions, I was not able to bestow my personal attention, during their progress, in consequence of a sprained ancle, which prevented me from making such personal examinations as I was accustomed to make on other parts of the route. Moreover it was known, at that time, that a grade of 25 feet per mile, would be eligible, on so extensive a portion of the route west of the mountain, as the subsequent serveys have made manifest. Nor on the completion of the surveys west of the mountain was there any opportunity presented for retracing the portion first mentioned; owing to the lateness of the season and the inclemency of the weather. These considerations induce me to suggest the propriety of a revision of that portion, even from Lilly's mill downward to the point where the 25 feet grade commences, with a view to an improvement of the location, which may perhaps be effected, by substituting an inclination of about 25 feet per mile as the general grade, instead of 13 to 16 which were the grades at which the location was made. The advantages that may be expected to result from such a revision are the crossing of Limestone run, at a less elevation, a reduction in the curvature of the 9th inclined plane, and the crossing of Ebensburg branch, by means of a less elevated embankment. In other respects, the route here adverted to would not probably differ materially from the located route.

In order to give a more distinct view of the route, and of the extent of the obstacles to be overcome, in the construction of the contemplated road, we shall regard it as divisible into 37 detached parts or sections, to be numbered in the order of their occurrence, from Johnstown eastward. The extent of the respective sections will be such, that the work required upon each, may be executed without interference with that on the adjacent sections.

PROBABLE COST OF CONSTRUCTION.

Preparatory to an estimate of the probable cost of construction, it will be proper to present a connected view of the amounts of excavation, embankment, walling, &c. on the several sections into which the route has been divided. The following table has accordingly been prepared, the contents of which are sufficiently explained in the headings of its several columns.

Synopsis of grading, masonry, &c. required in the construction of the contemplated portage road, computed for a surface width of 25 feet.

No. of section.	DISTANCE.		EXCAVATION.	EMBANKM'T.	MASONRY.
	Miles	Feet.	Cubic yards.	Cubic yards.	Perches.
1	2	1740	21776.69	27800.92	3376½
2		2000	4281.50	5849.04	31¼
3	1	1420	11113.47	17478.43	7924½
4		2400	25051.15	15110.68	106½
5	1	1520	6837.95	10968.43	779
6	1	2620	4190.59	22784.57	1238½
7		4000	12344.19	10283.56	2740
8	1	20	7474.97	9933.25	83¼
9		3900	8439.21	6387.97	62½
10	1	20	9876.67	8439.21	1483¼
11	1	32	9106.45	11113.74	213¼
12		2600	10941 44	11992.36	41½
13	1	1320	11187.39	17607.92	104
14	1	80	6074.79	18629.02	449¼
15	1	1320	11508.45	5120.89	1131
16		3900	10119.69	5252.51	2218½
17		4000	2758.86	3625.24	336
18		3900	6581.14	8891.11	62½
19	1	20	7786.91	9749.43	83¼
20		4000	8512.56	20240.88	399¼
21		3900	10540.50	17358.22	1683¾
22		4900	10190.11	2543.78	2118¼
23		4400	11541.47	7824.10	62½
24	1	3920	10335.81	7483.23	145½
25	1	20	6645.49	4816.11	83¼
26	1	20	9998.77	14473.06	83¼
27		3065	26755.32	2985.19	20¾
28		3700	9796.18	9710.42	1055¾
29		3400	5912.57	15647.56	951¼
30	1	294	13958.75	12132.60	5360¼
31		4511	5234.23	7637.93	210¼
32		4700	10930.66	14265.34	52
33	1	120	3368.51	4158.10	83¼
34		4200	2568.63	4999.48	78
35	1	920	2258.11	10456.57	198½
36	1	120	755.27	9977.48	215½
37	1	420	43.30	14125.97	10½
Aggregate,	35	4222	336797.75	406203 87	34278

The expenditures incident to the construction of the contemplated road may be classed under two distinct heads, viz :—those incurred in forming the road bed, and embracing the expense of clearing, grubbing, grading, walling and bridging, and those incurred in paving and railing, in which are to be included, the preparation of broken stone, for covering the surface of the road, the procuring of materials for rails, and their adjustment.

ESTIMATE OF THE PROBABLE COST OF ROAD FORMATION.

SECTION No. 1.—*Length, 2miles* 1740 *feet.*

Clearing 60 ft. wide, grubbing 30 ft. wide, 11200 ft. running measure at 4 cts.	$448 00	
Cubic yards common excavation, 15497.07, at 8	1239 77	
Do. fast rock, 1140.18 at 46	524 48	
Do. loose do. 5139.44 at 30	1541 83	
Do. embankment 27800.92 at 10	2780 09	
Perches bridge masonry 218.00 at $2	436 00	
Do. culvert do. 218.50 at $1	218 50	
Do. side wall 2940 00 at 75 cents	2205 00	
		$ 9393 67

SECTION No. 2—*Length* 2000 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 2000 feet running measure at 4 cts.	$80 00	
Cubic yards common excavation 2221.57 at 8	177 72	
Do. fast rock 686.64 at 46	315 85	
Do. loose do. 1373.28 at 30	411 99	
Do. embankment 5849.04 at 10	584 90	
Perches culvert masonry 31.25 at $1	31 25	
		$1601 71

SECTION No. 3—*Length* 1 *mile* 1420 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 6700 feet running measure at 4 cents	$ 268 00	
Cubic yards common excavation 2544.94 at 8	203 60	
Do. fast rock 5747.00 at 46	2643 62	
Do. loose rock 2821.53 at 30	846 46	
Do. embankment 17478.43 at 10	1747 84	
Perches culvert masonry 114.50 at $1	114 50	
Do. side wall 7810.00 at 75 cents	5857 50	
		$ 11681 52

SECTION No. 4—*Length* 2400 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 1400 feet running measure at 4 cts.	$56 00	
Cubic yds common excavation 2931.70 at 8	234 54	
Do. fast rock 5857.88 at 50	2928 94	
Do. loose rock 2928 24 at 30	878 47	
Do. embankment 15110.68 at 10	1511 07	
Perches bridge masonry 96 00 at $2	192 00	
Do. culverts do. 10.50 at $1	10 50	
Cubic yards of excavation for a tunnel 1000 feet long, exclusive of lining, 13333.33 at $2 25	30000 00	
		34011 52

SECTION No. 5—*Length* 1 *mile* 1520 *feet.*

Clearing 60 ft. wide, grubbing 30 ft. wide, 6800 ft. running measure at 4 cents	$ 272 00	
Cubic yards common excavation 3886.17 at 8	310 89	
Do. fast rock 1251.29 at 46	575 59	
Do. loose rock 1700.49 at 30	510 15	
Do. embankment 10968.43 at 10	1096 84	
Perches culvert masonry 114.50 at $1	114 50	
Do. side wall, 664 50 at 75	498 37½	
		3378 34½

SECTION No. 6—*Length* 1 *mile* 2620 *feet.*

Clearing 60 ft wide, grubbing 30 ft wide, 7900 ft running measure at 4 cents	316 00	
Cubic yds common excavation 2542.69 at 8	203 41	
Do. fast rock 611.97 at 46	281 51	
Do. loose rock 1035.93 at 30	310 78	
Do. embankment 22784.57 at 10	2278 45	
Perches culvert masonry 124.75 at $1	124 75	
Do. side wall 1113.75 at 75 cts	835 31	
		4350 21

SECTION No. 7—*Length* 4000 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 4000 feet running measure, at 4 cents	160 00	
Cubic yds common excavation, 5796.93, at 8	463 75	
do fast rock, 2696.12, at 50	1348 06	
do loose do 3851.14, at 30	1155 34	
do embankment, 10283.56, at 10	1028 35	
Perches, culvert masonry, 62.50, at $1	62 50	
Wooden bridge across the Conemaugh, 570 feet, running measure, at $15	8550 00	
Piers and abutments for do. perches, 2677.50, at $1 75	4685 62½	
		17453 62½

SECTION No. 8—*Length* 1 *mile* 20 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 5300 feet running measure, at 4 $\frac{53}{100}$ cents	240 00	

Cubic yds common excavation. 3983.31, at 8	318 66	
do fast rock, 1163.88, at 46	535 38	
do loose do 2327.78, at 30	698 33	
do embankment, 9933 25, at 10	993 32	
Perches, culvert masonry, 83.25, at $1	83 25	
		2868 94

SECTION No. 9—*Length* 3900 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 3900 feet running measure, at 5 cents	195 00	
Cubic yds common excavation, 5174.51, at 8	413 96	
do loose rock, 3264.70. at 30	979 41	
do embankment, 6387 96, at 10	630 80	
Perches, culvert masonry, 62.50, at $1	62 50	
		2289 67

SECTION No. 10—*Length* 1 *mile* 20 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 5300 feet running measure, at $5\frac{1}{10}$ cents	270 00	
Cubic yds common excavation, 4142.00, at 8	331 36	
do fast rock, 1833.66. at 46	843 48	
do loose do 3901.01, at 30	1170 30	
do embankment, 6779 79, at 10	677 98	
Perches, culvert masonry, 83.25, at $1	83 25	
do side wall, 1400.00, at 75	1050 00	
		4426 37

SECTION No. 11—*Length* 1 *mile* 32 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 5012 feet running measure, at 4 cents	200 48	
Cubic yds common excavation, 6070.97, at 8	485 68	
do fast rock, 605.91, at 46	278 72	
do loose do 2429 57, at 30	728 87	
do embankment, 11113.74, at 10	1111 37	
Perches, bridge masonry, 130.25, at $2	260 50	
do culverts do 83.25, at $1	83 25	
		3148 87

SECTION No. 12—*Length* 2600 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 1800 feet running measure, at 4 cents	72 00	
Cubic yds common excavation, 7127 63, at 8	570 21	
do fast rock, 1504.60, at 50	752 30	
do loose do 2309.21, at 30	692 76	
do embankment, 11992.56, at 10	1199 24	
Perches, culvert masonry, 41.50, at $1	41 50	
		3328 01

SECTION No. 13.—*Length* 1 *mile* 1320 *feet.*

Clearing 60 feet wide, grubbing 0 feet wide, 4700 feet running measure, at 4 cents,	188 00	
Cubic yards common excavation, 6512.44 at 8	520 99	
do fast rock, 945.82 at 46	435 08	
do loose do. 3729.13 at 30	1118 74	

Cubic yds embankment, 17607.92 at 10	1760	29		
Perches culvert masonry, 104.00 at $1 00	104	00		
			4127	10

SECTION No 14.—*Length* 1 *mile* 80 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 4100 feet running measure, at 3½	143	50		
Cubic yards common excavation, 1839.86 at 8	147	19		
do fast rock, 958.73 at 46	441	01		
do loose do 3276.20 at 30	982	86		
do embankment, 18629.02 at 10	1862	90		
Perches culvert masonry, 83,25 at $1 00	83	25		
Wooden bridge, across Ebensburg branch of Conemaugh, 80 ft. running measure, $15	1250	00		
Abutments for do. perches, 366.00 at $1 75	640	50		
			5551	21

SECTION No. 15.—*Length* 1 *mile* 1320 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 6600 feet running measure, at 4 cents	264	00		
Cubic yards common excavation, 8631.24 at 8	690	50		
do fast rock, 718.60 at 46	330	55		
do loose do 2158.61 at 30	647	58		
do embankment, 5929.89 at 10	512	99		
Perches culvert masonry, 104.00 at $1 00	104	00		
do side wall, 1027.00 at 75	770	25		
			3319	87

SECTION No. 16.—*Length* 3900 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 3900 feet running measure, at 4	156	00		
Cubic yards common excavation, 4501.78 at 8	360	14		
do fast rock, 4330.56 at 46	1992	06		
do loose do. 1287.35 at 30	386	20		
do embankment, 5252.51 at 10	525	25		
Perches culvert masonry, 62.50 at $1 00	62	50		
do side wall, 2157.00 at 75	1617	75		
			5099	90

SECTION No. 17.—*Length* 4000 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 4000 feet running measure, at 4 cents	160	00		
Cubic yards common excavation, 2758.86 at 8	220	71		
do embankment, 3625.54 at 10	362	55		
Perches bridge masonry, 129.00 $2 00	258	00		
do culvert do. 62.50 at $1 00	62	50		
Wooden bridge across the mountain branch of Conemaugh, 80 ft. running measure, at $15	1250	00		
Abutments for do. perches, 145.00 at $1 75	253	75		
			2567	51

SECTION No. 18.—*Length* 3900 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 3900 feet. running measure, at 4	156	00		
Cubic yards common excavation, 4387.41 at 8	350	99		

Cubic yds loose rock, 2 93.73 at 30	658 12	
do embankment, 8891.11 at 10	889 11	
Perches culvert masonry, 62.50 at $1 00	62 50	
		2116 72

SECTION No. 19—*Length* 1 *mile* 20 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 5300 feet running measure, at 5$\frac{1}{10}$ cents	270 00	
Cubic yds common excavation, 5840.19, at 8	467 21	
do loose rock, 1946.72, at 30	584 01	
do embankment. 9749.43, at 10	974 94	
Perches, culvert masonry, 83.25, at $1	83 25	
		2379 41

SECTION No 20—*Length* 4000 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 4000 feet running measure, at 5 cents	200 00	
Cubic yds common excavation, 6384.42, at 8	510 75	
do fast rock, 425.65, at 46	195 79	
do loose do 1702.51, at 30	510 75	
do embankment. 20240.88, at 10	2024 08	
Perches, bridge masonry, 336.75, at $2	673 50	
do culvert do 62.50, at $1	62 50	
		4177 37

SECTION No. 21—*Length* 3900 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 3900 feet running measure, at 5 cents	195 00	
Cubic yds common excavation, 5076.00, at 8	406 08	
do fast rock, 2104.12, at 46	967 87	
do loose do 3360.38, at 30	1008 11	
do embankment, 17358.22, at 10	1735 82	
Perches, bridge masonry. 394.75, at $2	789 50	
do culvert do 62.50, at $1	62 50	
do side wall, 1226.50, at 75	919 87½	
		6084 77½

SECTION No. 22—*Length* 4900 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 4900 feet running measure, at 5 cents	245 00	
Cubic yds common excavation, 6409.53, at 8	512 76	
do fast rock, 1221.99, at 46,	562 11	
do loose do 2558.54, at 30	767 56	
do embankment, 2543.78 at 10	254 37	
Perches, bridge masonry, 249.50, at $2	499 00	
do culvert do 72 75, at $1	72 75	
do side wall, 1796.00, at 75	1347 00	
		4260 55

SECTION No. 23—*Length* 4400 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 4400 feet running measure, at 5 cents	220 00	
Cubic yds common excavation, 8417.11, at 8	673 37	
do fast rock, 1041.45, at 46	479 06	

Cubic yds loose rock, 2082.91, at 30	624 87	
do embankment, 7824.10, at 10	782 41	
Perches, culvert masonry, 62.50, at $1	62 50	
		2842 21

Section No. 24—*Length* 1 *mile* 3920 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 9200 feet running measure, at 5 cents	460 00	
Cubic yds common excavation, 8288.65, at 8	683 09	
do loose rock, 2047.16, at 30	614 14	
do embankment, 7483.23, at 10	748 32	
Perches, culvert masonry, 145.50, at $1	145 50	
		2651 05

Section No. 25—*Length* 1 *mile* 20 *feet.*

Clearing 60 ft wide, grubbing 30 ft wide, 5300 ft running measure at 5 cents	265 00	
Cubic yards common excavation 5316 39 at 8	423 31	
do loose rock 1329 10 at 30	398 73	
do embankment 4816.11 at 10	481 61	
Perches culvert masonry 83.25 at $1	83 25	
		1653 90

Section No. 26—*Length* 1 *mile* 20 *feet.*

Clearing 60 ft wide, grubbing 30 ft wide, 5300 ft running measure at 5 cents	$265 00	
Cubic yds common excavation 8003 02 at 8	640 24	
do loose rock 1995.75 at 30	598 72	
do embankment 14478.06 at 10	1447 80	
Perches culvert masonry 83.25 at $1	83 25	
		3034 51

Section No. 27—*Length* 3065 *feet.*

Clearing 60 ft wide, grubbing 30 ft wide, 2565 ft running measure at 4 cents	$ 102 60	
Cubic yds common excavation 17837.32 at 15	2675 60	
do fast rock 4459.00 at 50	2229 50	
do loose rock 4459.00 at 30	1337 70	
do embankment 2985.19 at 10	298 52	
Perches culvert masonry 20.75 at $1	20 75	
		6664 67

Section No 28—*Length* 3700 *feet.*

Clearing 60 ft wide, grubbing 30 ft wide, 3300 ft running measure at 4 cents	132 00	
Cubic yds common excavation 6904.18 at 8	552 33	
do fast rock 1233.00 at 46	567 18	
do loose rock 1659.00 at 30	497 70	
do embankment 9710.42 at 10	971 04	
Perches bridge masonry 300.25 at $2	600 50	
do culvert do 52 at $1	52 00	
do side wall 703.50 at 75 cts	527 62½	
		3900 37½

Section No. 29—*Length* 3400 *feet.*

Clearing 60 ft wide, grubbing 30 ft wide, 3400 ft running measure at 4 cents	$136 00	

Cubic yds common excavation 2957.57 at 8	236	60		
do loose rock 2955.00 at 30	886	50		
do embankment 15647.56 at 10	1564	75		
Perches bridge masonry 143.00 at $2	286	00		
do culvert do 52.00 at $1	52	00		
do side wall 756.25 at 75 cts	567	18¾		
			3729	03¾

SECTION No. 30—*Length* 1 *mile* 294 *feet.*

Clearing 60 ft wide, grubbing 30 ft wide, 5394 ft running measure at 4 cts	$215	76		
Cubic yds common excavation 9555.73 at 8	764	45		
do loose rock 4403.00 at 30	1320	90		
do embankment 12132.60 at 10	1213	26		
Perches bridge masonry 217.25 at $2	434	50		
do culvert do 83.25 at $1	83	25		
do side wall 5059.75 at 75	3794	81¼		
			7826	93¼

SECTION No. 31.—*Length* 4511 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 4511 feet, running measure, at 4 cents	180	44		
Cubic yards common excavation, 4734.23 at 8	378	73		
do loose rock, 500.00 at 30	150	00		
do embankment, 7637.93 at 10	763	79		
Perches bridge masonry, 158.25 at $2 00	316	50		
do culvert do 52.00	52	00		
			1841	46

SECTION No. 32—*Length* 4700 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 4700 feet, running measure, at 4 cents	188	00		
Cubic yards common excavation, 6540.66 at 8	523	25		
do fast rock, 1740.00 at 46	800	40		
do loose do 2650.00 at 30	795	00		
do embankment, 14265.34 at 10	1426	53		
Perches culvert masonry, 52.00, at $1	52	00		
			3785	18

SECTION No. 33.—*Length* 1 *mile* 120 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 3700 feet running measure, at 4 cents	148	00		
Cubic yards common excavation, 3368.51 at 8	269	48		
do embankment, 4158.10 at 10	415	81		
Perches culvert masonry, 83.25 at $1	83	25		
			916	54

SECTION No. 34.—*Length* 4200 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 3600 feet, running measure, at 4 cents	144	00		
Cubic yards common excavation, 2568.63 at 8	205	49		
do embankment, 4999.48 at 10	499	94		
Perches culvert masonry, 78.00 at $1	78	00		
			927	43

Section No. 35.—*Length* 1 *mile* 920 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 3600 feet running measure, at 4 cents	144 00	
Cubic yards common excavation, 2258.11 at 8	180 65	
do embankment, 10456.57 at 10	1045 65	
Perches bridge masonry, 167.50 at $2 00	335 00	
do culvert, do 31.00 at $1	31 00	
		1736 30

Section No. 36.—*Length* 1 *mile* 120 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 1000 feet running measure, at 4 cents	40 00	
Cubic yards common excavation, 755.27 at 8	60 42	
do embankment, 9977.48 at 10	997 74	
Perches bridge masonry, 205.00 $2 00	410 00	
do culvert do. 10 50 at $1	10 50	
		1518 66

Section No. 37.—*Length* 1 *mile* 420 *feet.*

Clearing 60 feet wide, grubbing 30 feet wide, 900 feet running measure, at 4 cents	36 00	
Cubic yards common masonry, 43.30 at 8	3 46	
do embankment, 14125.97 at 10	1412 59	
Perches culvert masonry, 10.50 at $1	10 50	
		1462 55
Estimated aggregate cost,		$182,107 68

Thus it appears, that the aggregate cost on account of road formation, on the route treated of in this paper will be, one hundred and eighty two thousand one hundred and seven dollars sixty-eight cents, which gives for the average expense per mile, inclusive of a tunnel one thousand feet long, five thousand and eighty six dollars, fifty-nine cents.

With respect to the allowances for the different kinds of excavation, designated in the foregoing estimate as "fast rocks," "loose rocks," and "common excavation," they are such as the indications upon the surface of the ground seemed to justify. Their accuracy can be tested only by the actual execution of the work.

OF RAILING AND PAVING.

In view of the nature of the ground over which the route passed and of the materials presented for the construction of a rail road, the method of railing which I think proper to recommend as best adapted to the construction of the portage road; as also to the economy, efficiency and permanency of the work. is that of stone rails or cills placed longitudinally of the road, firmly imbedded in rubble stone, and supporting iron plate rails two inches wide and five eighth inch thick. This method has been successfully applied in several places, and fully answered the expectations that lead to its adoption, and the purposes for which it was intended.

The proposed width of each rail track, inclusive of the rails, is five feet and six inches in the clear, or between the rails four feet and six inches. That of the space intervening between the two tracks three feet. Average thickness of each rail, six inches,—or varying from five to eight inches,—depth of rail twelve to eighteen inches,—length three to eight feet.

Without entering farther into details explanatory of this method, I shall attempt an estimate of the probable expense of construction, in conformity to the plan suggested. grounding my views on the belief that the quarries of the Allegheny mountain, and its adjacent hills, will afford inexhaustible supplies, extremely easy of access; of the most convenient fracture, and every way suitable for rails of this description.

Probable cost of paving and railing, with double tracks, one mile of the contemplated Rail-road.

40 tons of iron rails, prepared for laying, 2 inches wide by five-eighths inch thick, at $70	$2800 00
1582 lbs. iron rivets, 3 inches long and three-eighths inch in diameter, to be set at intervals of 15 inches in each rail, at 10 cents per lb.	158 20
21120 feet running measure of stone rails, deliverd on the route, at 15 cents per foot	3168 00
Laying 21120 feet of stone rails, the dressing of their ends and upper edges, drilling for rivets, &c. being included, at 7 cents per foot	1478 40
1 mile in length of M'Adamized pavement, 4 inches thick, and 20 feet wide, including rubble stone for confining stone rails	1200 00
Contingencies, including the conveyance of sundry materials, fastening of the iron rails, &c.	1195 40
Add 20 per cent. for turns-out, bolting-tracks, &c.	2000 00
Amounting to	$12,000 00

This amount added to the estimated cost of grading, bridging, &c. heretofore exhibited, will give for the cost of the rail-road per mile, seventeen thousand and eighty-six dollars, fifty-nine cents, or for the aggregate cost on the entire route under consideration, inclusive of the tunnel at the Lower Bend of the Conemaugh, six hundred and eleven thousand seven hundred dollars.

It will be perceived that nothing has been advanced in this paper, in relation to the manner and cost of transportation on the contemplated rail-road. My views and opinions on these subjects will be cheerfully communicated, should you require an expression of them. I have the honor to be, gentlemen,

Very respectfully,
Your most ob't. ser't.
S. H. LONG, *Bt. Lt. Col.*

Philadelphia, February 28th, 1831.
To Frs. R. Shunk, Esq.
Sect. Bd. of Canal Commissioners, Harrisburg.